Ash and Solids Assessment

After the Kingston ash spill, TVA, TDEC, and EPA sampled local ash, soil and subsoil, and river sediments. Samples were taken in the former dredge cell, in the embayment, at private residences, and several locations in the Emory River and have enabled us to explore the physical and chemical characteristics of ash. The information assisted TVA and regulators in designing additional studies to determine whether the ash spill could have residual impacts to native soil or cause elevated risk to human health and the environment.

Physical characteristics

Coal is pulverized to a powder before being burned in a power plant. This allows better contact with air and more rapid and complete combustion. Much of the ash that remains after combustion is a fine powder made up of spherical particles. This fine material is called fly ash, which is gray to black and has a consistency similar to flour. The Kingston plant consumes approximately 14,000 tons of coal every day when operating at full power, which results in about 1000 tons of fly ash per day.

Fly ash can be used to improve the quality of many building products like cement, mortar, stucco, and grout. It also is used in some potting soils and as a soil conditioner. Cenospheres, ash particles formed around bubbles of flue gas, have their own uses as lightweight fillers.

About 2/3 of KIF fly ash particle consists of particles in the silt size range (0.005 to 0.075 mm). Another sixth of the particles are clay size (smaller than 0.005 mm), and the remaining particles are in the fine sand size category. Smaller particle sizes were a major focus for dust control activities on the recovery site, and could be more easily moved downstream by flowing river water.

Chemical Characteristics

The chemical composition of fly ash varies depending on the source of the coal. KIF mostly burns Eastern bituminous coal but has also used coal from Illinois, and blends low-sulfur Western coal to reduce emissions. In addition, there are pockets of bottom ash mixed with the fly ash. The bottom ash contains some pieces of pyrite rejected by the coal grinding process. These fragments are predominantly iron sulfide (FeS_2) but also may have a different trace element composition than the ash.

The principal chemical components of fly ash are those that are typical of rock and soil. Oxides of silicon, aluminum, iron, and calcium, chemically combined in an amorphous (non-crystalline, or glass-like) form, comprise 95% to 99% of fly ash. Ash also contains variable but significant amounts (0.5% to 3.5%) of magnesium, titanium, sulfur, sodium, and potassium.

Table 1. Major chemical components of KIF fly ash.

	Average KIF Fly Ash composition (%)
Silicon Dioxide	55.3
Aluminum Oxide	27.8
Iron Oxide	6.8
Calcium Oxide	3.0
Magnesium Oxide	1.4
Sodium Oxide	0.7
Potassium Oxide	2.3
Titanium Dioxide	1.3
Sulfite Trioxide	0.6
Phosphorus Pentoxide	0.3

Trace Elements and Constituents of Interest

Though the main chemical components of ash are relatively benign, ash may contain trace amounts of other substances. These trace elements are mostly chemically combined with the other components of the ash. The tendency of these metals to be dissolved in water or otherwise become available to organisms (bioavailability) is difficult to predict because it depends not only on the specific ways the metals are chemically combined or bound, but also on many other factors, including temperature, pH and hardness of water, availability of oxygen, and amount of agitation.

Because they have been found in analyses of coal ash in the past, the following metals and metalloids are considered constituents of interest (COI) related to fly ash: arsenic, chromium, copper, lead, mercury, nickel, selenium, thallium, vanadium, zinc, and the naturally-occurring radionuclides, specifically isotopes of uranium and thorium, their short-lived daughter products, and potassium-40. These COIs occur naturally in coal and are concentrated in the ash remaining after combustion.

Metals and Metalloids

While ash is not natural soil, comparing it with regional “background” soils can be helpful. Ash and soil share many common ingredients, so a comparison of their concentration levels can provide perspective. Background levels are based on trace element surveys published by the Tennessee Department of

Environment and Conservation and the Department of Energy, along with TVA, TDEC, and EPA measurements in the KIF region.

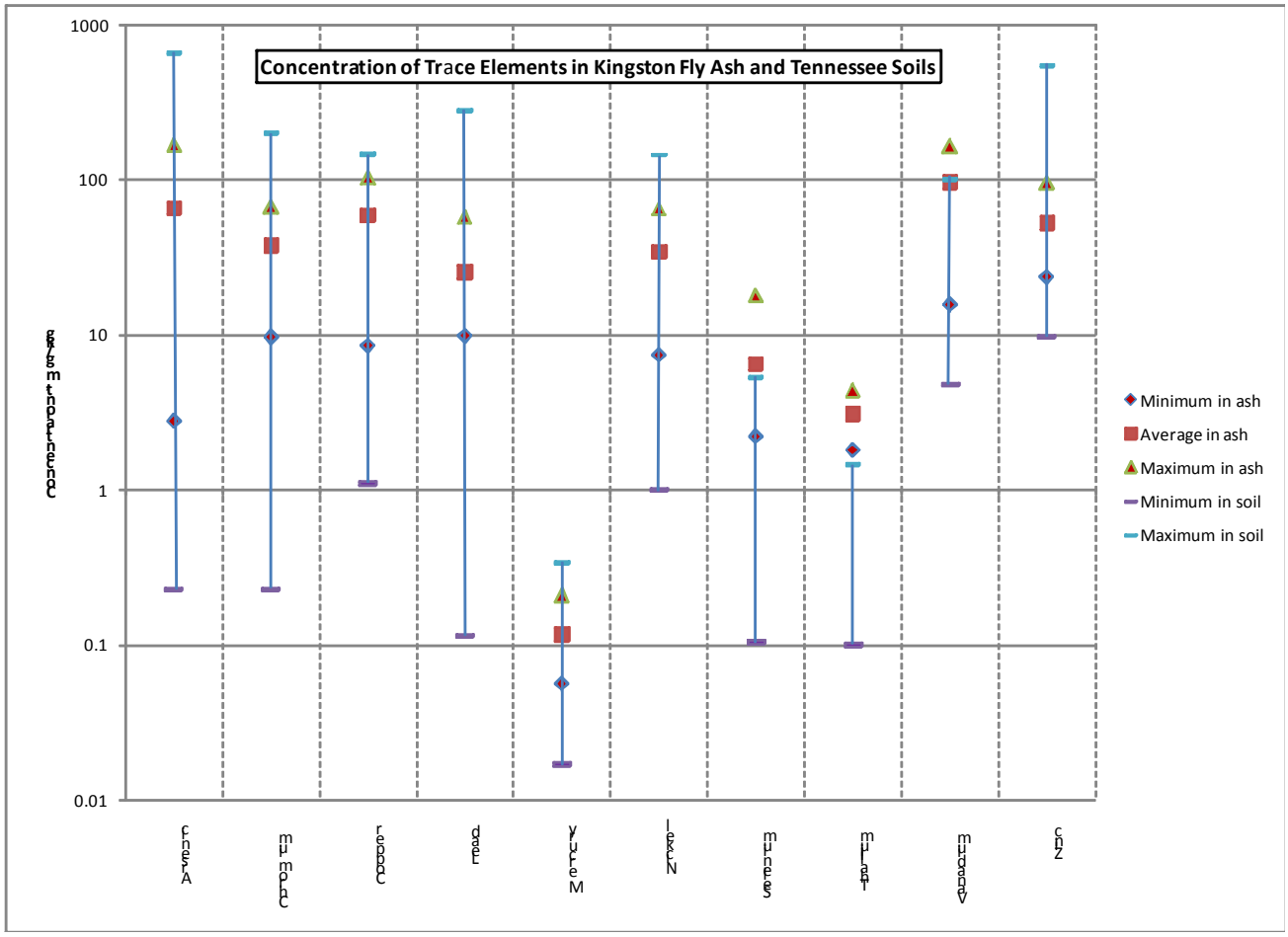
The levels of most of the metals and metalloids are within the range found in soils in Tennessee. Only selenium, thallium, and vanadium were clearly above background levels (see figure).

Selenium concentration varied widely in ash samples, with an average concentration higher than local sediment, soil and bedrock samples. Thallium was not detected in soil or subsoil and only detected in nine of 57 ash samples. Vanadium was slightly higher in ash than other sample types.

Mercury values were low (4 of 61 ash samples had detectable amounts) except at ERM 0.5 where, over the decades, backflow from the Clinch has allowed mercury released from Department of Energy functions in Oak Ridge to migrate upstream. Mercury in many local soil samples was below the detection limit, but was detected in 17 of 61 samples in soil and subsoil formed over Knox group rock.

Arsenic is widely distributed in the natural environment. Arsenic levels measured in soils range from 6.4 to 655 mg/kg, with 10 mg/kg considered a typical background level. Arsenic concentrations in soil and subsoil formed over Knox group rock near the KIF site were as high as 102 mg/kg. Because arsenic is present in some fertilizers and arsenic-based pesticides were commonly used as recently as the 1950's, background soil samples with concentrations above 180 mg/kg may have been influenced by past agricultural practices. Arsenic concentrations in ash samples collected by TVA ranged from 2.78 to 166 milligrams per kilogram (mg/kg), with an average of 65 mg/kg.

Chart 1. Comparing Trace Elements in Kingston Fly Ash to Tennessee Soils



Radioisotopes

Ash is known to contain naturally-occurring radionuclides, specifically isotopes of uranium, thorium, and potassium-40, and their short-lived daughter products. Radioactivity levels in ash are similar to those of typical regional soils. An exception is that levels of radium-226 generally exceed those of regional soils. Levels of radium-226 in regional soils typically range from 0.5 to 2 picocuries per gram (pCi/g), whereas those in ash range between 4.5 and 9 pCi/g.

More information

Hazardous Trace Elements in Tennessee Soils and Other Regolith., TDEC, Division of Geology, 2001

Soil Background Supplemental Data Set for the East Tennessee Technology Park, Oak Ridge, TN, Bechtel Jacobs Company LLC, 2003.

TDEC Soils and Ash Sampling